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Provision of ecological infrastructures to increase pollinators and other beneficial organisms in rainfed crops in Central Spain

Elisa Viñuela[1], Ángeles Adán[1], Joaquín Rodríguez[1], Sara Hernando[1], José Dorado[2], César Fernandez-Quintanilla[2], Germán Canomanuel[3] & Alberto Fereres[4]

[1]*Protección de Cultivos, E.T.S.I. Agrónomos, UPM, 28040 Madrid, Spain;* [2]*Weed ecology Group, Instituto de Ciencias Agrarias-CSIC, C/Serrano 115 dpdo., 28006 Madrid, Spain;* [3]*Dpto. Asuntos Reglamentarios. Syngenta Agro S.A., C/Ribera Del Loira 8-10, 28042 Madrid, Spain;* [4]*Dpto. de Protección Vegetal, Instituto de Ciencias Agrarias-CSIC, C/Serrano 115 dpdo., 28006 Madrid, Spain*

Abstract: In sustainable intensive agriculture, the biodiversity of monoculture fields can be increased by managing the field margins to provide ecological infrastructures that serve as refuges and resources for beneficial organisms (pollinators and natural enemies). In the present work we summarize two years of field trials following the goal to increase biodiversity of beneficial fauna in a barley field in Central Spain by sowing different herbaceous mixtures in the field margins. The presence of arthropods visiting flowers on plots sown with different types of seed mixtures and unsown natural flora (control plot) was compared by visual sampling every week between April and June. The results showed that a combination of herbaceous big-size seeds was the most successful mixture emerging under our experimental conditions and achieved a higher number of visits of beneficial arthropods than the unsown natural vegetation.

Key words: field margins, pollinators, natural enemies, herbaceous plants

Introduction

Plant-pollinator interactions are of crucial importance for natural communities and for agriculture. Many crops cannot be economically produced in absence of bees or bumblebees and at the same time, the disappearance of certain plants can lead to the extinction of some pollinator species (Ollerton, 1999). The contribution of insect pollination to the world agricultural output was estimated to represent 9.5% of the value of the world agriculture production devoted to human food (Gallai et al., 2009). On the other hand, pest control in modern agriculture is undertaken under integrated pest management (IPM), where Biological Control is one of the main strategies nowadays (Medina et al., 2008). IPM will be compulsory in the European Union by 2014 following the implementation of the EU directive 2009/128/EC (Doue, 2009). However, the intensive cultivation techniques applied in recent decades to agriculture, have removed important habitats and food sources that are essential for beneficial fauna, and reduced overall biodiversity of fauna and flora (Rands & Whitney, 2010).

In 2009 in UK, the action European Pollinator Initiative was launched (EPI, 2011). The Project Operation Pollinator, a part of the EPI, aimed to stop the decline of pollinators (Operation Pollinator, 2011). In the present work we summarize two years of field surveys in Central Spain that focused on the identification of pollinators and other beneficial arthropods visiting flowers provided by herbaceous mixtures sown in the margins of a barley field.

Material and methods

The study was carried out in 2010 and 2011 at the CSIC experimental farm "La Poveda" located at Madrid province in Central Spain. The interest was focused on 5 pollinator categories: honey bees, bumblebees, mining bees, megachilids and other flower-visiting arthropods.

In 2010, two side borders of an experimental barley field (120m long and 40m wide) were sown with 3 mixtures of herbaceous plants with different seed sizes (big, small and a combination of both; Table 1) or left unsown as control after plowing. Four plots (5m long and 3m wide) per treatment on every border were used. Initially, a destructive sampling with a sweeping net was done to identify the richness of beneficial fauna present in the area. In dry and warm countries such as Spain, insects fly very fast and it is not possible to identify them correctly unless first captured and observed under a binocular. Later on, a direct visual sampling was conducted weekly starting at the time flowers started to bloom. The number of arthropod visits to flowers during 4 minutes in the central area of each of the four experimental plots (5m long each) was recorded.

In 2011, based on the results obtained in the previous year, another mixture of herbaceous plants with big-size seeds and an unsown control were established in a different location of the farm (Table 1). This time, only one of the margins of a barley field (177.5m long) was used for the study and the number of arthropod visits to flowers was determined. Six plots (5m long and 3m wide) per treatment were used. This year, a Nikon D90 camera with a macro lens (Sigma 150mm 1:2.8) was used instead of the sweeping net to determine the diversity of pollinators and other beneficial arthropods present on the experimental site. Later on, the same direct visual sampling method as previously described was conducted when flowers started to bloom.

Moreover, in both years the floral canopy coverage of sown or unsown plant species in the different plots was estimated. Samplings were conducted weekly from April to beginning of June between 9:30 a.m. and 12:30 p.m.

Results and discussion

Floral coverage

The species of herbaceous plants that flowered on the sown plots and the natural vegetation that emerged in the margins of a barley field in 2010 and 2011 are shown in Table 1.

In the first year of study, plants included in the mixture "big seeds" had better emergence and better competitiveness with wild flora, than those of the "small seeds". *Coriandrum sativum* (L.) was clearly the dominant species followed by *Cnicus benedictus* (L.) and *Vicia sativa* (L.) and to a lesser extent, *Pimpinella anisum* (L.). In contrast, most of the plants included in the mixture "small seeds" did not emerge at all or represented only a small percentage of the floral coverage (*Matricaria chamomilla* (L.) and *Moricandia arvensis* D.C.). In these plots, unsown natural vegetation of the genus *Papaver, Fumaria* and the family *Poaceae* was dominant. In the combined big and small-seed plots again *C. sativum* and *V. sativa* were dominant among the sown plants, but the unsown *Papaver* was predominant. In control plots, *Papaver* species were the dominant plants, but species of the genus *Fumaria* and family Poaceae were very common.

In 2011, the mixture of "big seeds" was more successful than that of 2010. Only *Melilotus officinalis* (L.), *Salvia verbenaca* (L.) and *Nigella damascena* (L.) did not emerge at all and unsown plants were unusual in the seeded plots. *Diplotaxis* sp. and *C. sativum* exhibited the earliest bloom and took up most of the available soil surface. *Calendula officinalis* (L.), *B. officinalis* and *Echium* spp. started blooming next showing a spectacular combination of colours. Half of the control plots were dominated by *Fumaria* spp., *Asperugo procumbens* (L.), *Chenopodium album* (L.) and in lesser extent, *Papaver* spp. and *Matricaria chamomilla* (L.). In the rest, the only species present was *C. album*.

Table 1. Plants sown and natural unsown vegetation in the field margins of a barley crop in Central Spain.

2010		
Plant mixture	**Sown**	**Unsown**
Small-size seeds	*Matricaria chamomilla* L.*, *Medicago sativa* L.^{0}, *Melilotus officinalis* L.^{0} *Moricandia arvensis* D.C.*, *Nigella damascena* L.^{0}, *Taraxacum officinalis* Wigger ^{0}	*Fumaria* spp.*, *Papaver* spp.***, Poaceae*
Big-size seeds	*Borago officinalis* L.^{0}, *Cnicus benedictus* L.**, *Coriandrum sativum* L.***, *Echium* spp.^{0}, *Onobrychis viciifolia* Scop.^{0} *Pimpinella anisum* L.*, *Vicia sativa* L.**	*Asperugo procubens* L.**, *Papaver* spp.*
Combination of small- and big-size seeds	*B. officinalis* ^{0}, *C. sativum***, *Echium* sp.^{0}, *M. chamomilla**, *M. officinalis*^{0}, *M. arvensis*^{0}, *O. viciifolia*^{0}, *P. anisum*^{0}, *V. sativa***, *T. officinalis*^{0}	*Papaver* spp.***
Control: unsown		*A. procubens**, *Fumaria* spp.**, *Papaver* spp.***, Poaceae**
2011		
Big-size seeds	*Borago officinalis* L.***, *Calendula officinalis* L.**, *Coriandrum sativum* L.**, *Diplotaxis* spp.***, *Echium* spp. L.*, *Melilotus officinalis* L.^{0}, *Nigella damascena* L.^{0}, *Salvia verbenaca* L.^{0}, *Silene vulgaris* M.*, *Vicia sativa* L.*	*Fumaria* spp.*, *Chenopodium album* L.*, *Papaver* spp.*
Control: unsown natural vegetation		*Asperugo procubens* L.**, *C. album***, *Fumaria* spp. ***, *Matricaria chamomilla* L.*, *Papaver* spp.*

^{0} no emergence; * small coverage; ** important coverage; ***dominant

Arthropod visits to flowers

In 2010 the destructive sampling with the sweeping net showed that the three commonest groups of Hymenoptera pollinators were *Apis mellifera* L., *Bombus* spp. and mining bees. In 2011, rather similar results were obtained with the photo sampling procedure. The cumulative number of arthropod visits to flowers is shown in Table 2. In 2010, Coleoptera widely surpassed the other groups, but in 2011, they were not so well represented. The family Syrphidae had a good representation both years with several aphidophagous species. In 2011, Hymenoptera were very common and different species of mining bees, megachilids and *Apis* were observed. Number of pollinators was higher in plots with sown plants, especially within the group of Hymenoptera (129 visits in plots sown with herbaceous plants and only 17 in the control plots in 2011).

In conclusion, compared to mixtures of small-size seeds the mixture of big-size seeds seems to be very convenient because it offers the advantage of being easily sown with machinery. This big-seed selection will save money and time to farmers and will provide uniform and long-lasting flowers to attract pollinators and other beneficial arthropods.

Table 2. Cumulative number of arthropod visits to flowers during each sampling period per year in the margins of a barley field in Central Spain.

		2010		
Arthropods	**Small seeds**	**Big seeds**	**Small+Big seeds**	**Control (unsown)**
Apoidea	12	39	23	5
Apis mellifera	-	10	7	3
Bombus spp.	6	5	3	-
Megachilidae	-	-	-	-
Mining bees	6	24	13	2
Coleoptera	273	273	327	149
Syrphidae	150	190	134	118
TOTAL	435	502	484	272
2011				
Apoidea		129		17
Apis mellifera		39		6
Bombus spp.		8		10
Megachilidae		14		1
Mining bees		68		-
Coleoptera		38		36
Syrphidae		154		89
TOTAL		321		142

2010: 8 replicates of 4 minutes observation period/day in 6 sampling days. 2011: 6 replicates of 4 minutes observation period/day in 9 sampling days.

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